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Demographic studies on three selected species of *Terminalia* in the Kerala part of Western Ghats, South India

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Abstract

The study was conducted in forests of Kerala part of Western Ghats to assess demography and regeneration status of Terminalia paniculata, T. elliptica and T. travancorensis. About 52 ha was enumerated in Northern, Olavakode, Central, Highrange and Southern zones of the State. Among the three species, T. paniculata occupied about 77% of the study area with an increasing trend in tree density from Notrhtern to Southern zones. On the other hand, T. elliptica occupied 46% and found to have a decreasing trend in tree density. Distribution of T. travancorensis was only 2% of the study area, which was recorded in Olavakode, Central and Highrange zones. Study revealed that T. paniculata is dominant among the three species. However, regeneration of T. paniculata was poor compared to T. elliptica. Very poor regeneration was reported for T. travancorensis. The study indicates necessity to conserve the species due to their economical and ecological importance.

Keywords: Density, frequency, regeneration, *Terminalia elliptica*, *Terminalia paniculata*, *Terminalia travnacorensis.*

Introduction

Western Ghats is one among the best representatives of non-equatorial tropical evergreen forests in the world[1]. Though it covers only about 5% of India's total land area, it occupies more than 27% of total plant species. Due to the high level of biodiversity and endemism, it has been acknowledged as one of the biodiversity 'hotspots' of the world[2]. However, one of the major concerns in this biodiversity rich patch is the regeneration of species[3]. Similarly, assessment of demography of species is useful to identify constraints of the species. Anthropogenic intervention is one of the factors for poor regeneration of a species, which should be reduced to enhance replacement of older trees.

The genus *Terminalia* belonging to the family Combretaceae is a major component of moist tropical forests. *Terminalia bellirica* (Gaertn.) Roxb., *T. chebula* Retz., *T. cuneata* Roth, *T. elliptica* Willd., *T. paniculata* Roth and *T. travancorensis* Wt. & Arn. are the species distributed in the forest type. Wood and other produces make them commercially important. It is reported that natural regeneration of species like *T. elliptica* and *T. paniculata* is deficient[4,5]. Detailed investigation on the species in Kerala part of Western Ghats was scarce. Hence, the study was conducted to understand population structure and regeneration status of *T. elliptica*, *T. paniculata* and *T. travnacorensis*.

One of the major components of moist deciduous forests in Kerala part of Western Ghats is *T. elliptica*. Another component of the forest type is *T. paniculata*, which is endemic to peninsular India. Timber and bark of both species are used for construction and traditional medicines. Seeds of *T. paniculata* characteristically display very low germination[6]. *Terminalia travacorensis* is an endemic tree rarely found in evergreen forests of Kerala. No detailed report is available on distribution and regeneration status of the species. Considering economical and ecological significance, the study was undertaken focused on population status of above three *Terminalia* species in the forests of Kerala.

Materials and methods

Enumeration for the species (*T. elliptica*, *T. paniculata* and *T. travnacorensis*) was carried out in forests of five zones in the Kerala part of Western Ghats (Figure-1). Kerala State has a tropical, warm, humid monsoonal climate with South-West (June-November) and North-East (December - February) monsoons[7]. Average annual data for rainfall is 3000 mm, atmospheric temperature is 27°C and relative humidity is 64 - 93%. Two hundred and eighteen temporary plots (belt transect of 5 m width) with a total area of 51.7 ha were established in Northern, Olavakode, Central, Highrange and Southern zones along the forested tracts in Kerala to assess structural status of the species. Size of plots varied (500 to 1000 m) depending on the area and occurrence of the species.

Measured growth parameters (height and girth at breast height) of mother trees and associated species from each plot. Enumerated regeneration of the *Terminalia* species from sub-plots (5 x 100 m) within the plot. Grouped the regeneration into three girth classes, *viz*., ≤3 cm (seedlings), 3.1 to 10 cm (saplings) and 10.1 to 30 cm (poles)[8,9]. Seedlings were grouped as <50 cm, 50-100 m and >100 cm. Phytosociological analysis

was done using the software InventNTFP[10]. Statistical analysis (ANOVA) was performed on the data to find out any significant difference between zones.

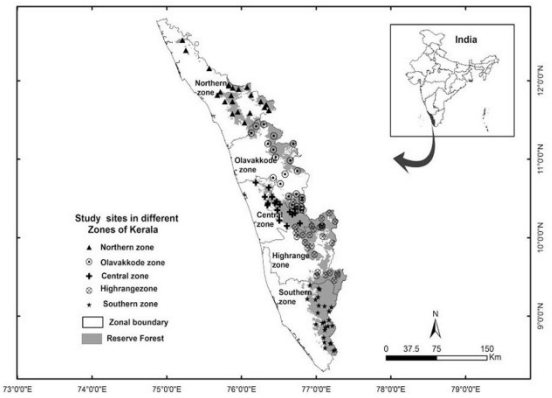

Figure-1: Study sites in different zones of Kerala.

Results and discussion

Structural status of tree communities: Table-1 represents the status of *Terminalia* species among tree community in the study areas. Two hundred and fifty nine tree species were recorded in five zones. Dominant in the associated species of *T. elliptica*, *T. paniculata* was *Xylia xylocarpa* (Roxb.) Taub. as reported in earlier investigation[11], followed by *Lagerstroemia microcarpa* Wight, *Tectona grandis* L. f., *Pterocarpus marsupium* Roxb., *Grewia tiliifolia* Vahl, *T. bellirica* (Gaertn.) Roxb., etc. Similarly, *Aglaia malabarica* Sasidh., *Chukrasia tabularis* A. Juss., *Cullenia exarillata* Robyns, *Dysoxylum malabaricum* Bedd. *ex* Hiern in Hook. f., *Hopea parviflora* Bedd., *Knema attenuata* (Hook. f. and Thoms.) Warb., *Myristica malabarica* Lam., *Palaquium ellipticum* (Dalz.) Baill., *Schleichera oleosa* (Lour.) Oken, etc., were the major associated species of *T. travancorensis*. Richness and diversity of species was high in the study areas (Margalef's Index - 26.93; Shannon's Index - 3.71).

Table-1: Basic statistics related to tree community, with special reference to the three species of *Terminalia* in the study sites of Kerala.

Sl. No.	Parameters		
1	Total number of plots studied		218
2	Total area (ha)		51.70
3	Total number of species		259
4	Dominant tree species		*Terminalia paniculata* *Xylia xylocarpa* *Terminalia elliptica* *Lagerstroemia microcarpa* *Tectona grandis* *Pterocarpus marsupium* *Grewia tiliifolia* *Terminalia bellerica*
5	No. of plots where trees of *Terminalias* occur	*Terminalia elliptica*	101
		Terminalia paniculata	168
		Terminalia travancorensis	5
6	Total tree density (individuals ha^{-1})		294.70 ± 4.85
7	Contribution of *Terminalias* to tree density (% of total tree density)	*Terminalia elliptica*	6.45
		Terminalia paniculata	22.78
		Terminalia travancorensis	0.16
8	Total basal area of tree community (m^2 ha^{-1})		36.6
9	Contribution of *Terminalias* to basal area of tree community (% of total basal area of tree community)	*Terminalia elliptica*	9.56
		Terminalia paniculata	26.23
		Terminalia travancorensis	0.55
10	Contribution of *Terminalias* to IVI of tree community (% of total IVI of tree community)	*Terminalia elliptica*	6.35
		Terminalia paniculata	18.05
		Terminalia travancorensis	0.33

Figure-2 (A) depicts an overall comparison of tree density and Importance Value Index (IVI) of the Terminalia species. Similarly, Figure-2 (B & C) represents tree density and IVI of *T. elliptica* and *T. paniculata* at each zone. Distribution status of *T. travancorensis* is depicted in Figure-2 (D). Number of trees in species, *T. paniculata* and *T. elliptica* between zones was significantly different (P≤0.01 and P≤0.05).

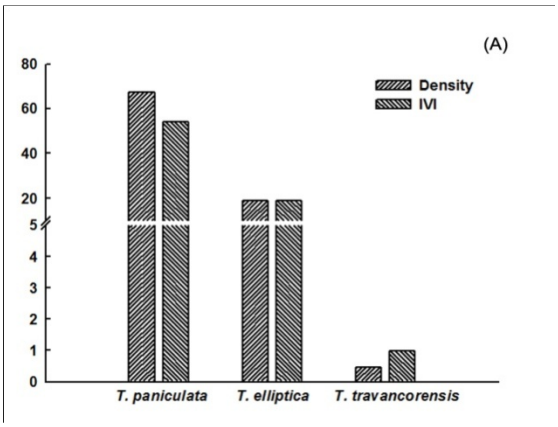

Figure-2(A): Overall comparison (Tree density and Importance value index - IVI) of *Terminalia paniculata*, *T. elliptica* and *T. travancorensis* in the study sites of Kerala.

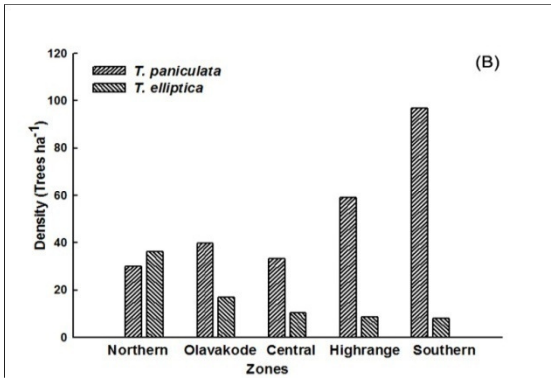

Figure-2(B): Tree density of *T. paniculata* and *T. elliptica* in the study sites at different zones.

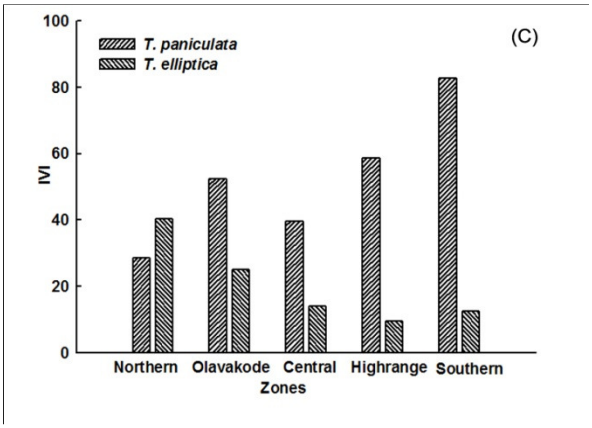

Figure-2(C): IVI of *T. paniculata* and *T. elliptica* in the study sites at different zones.

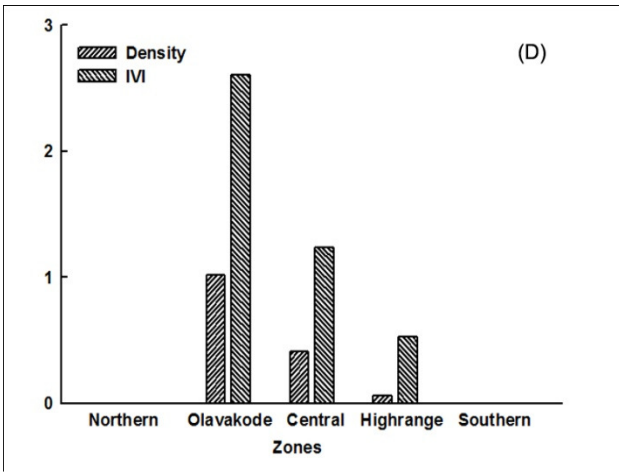

Figure-2(D): Tree density and IVI of *T. travancorensis* in the study sites at different zones.

Among the three species in tree community, higher distribution was recorded in *T. paniculata*. The result showed a stable population in mature trees of *T. paniculata* than the other *Terminalia* species. The study also revealed only a minimal distribution of *T. travancorensis* in limited localities. Hence, considering the low population density there is an urgent need to conserve the species.

Density and dominance was higher for *T. elliptica* in Northern zone, but in other zones *T. paniculata* was dominant among the three species. An increasing trend on population of *T. paniculata* was observed from Northern to Southern zones and vice versa in *T. elliptica* (Figure-2 B and C).

Regeneration of Terminalias: Overall regeneration status of *T. elliptica* and *T. paniculata* is given in Table-2. Regeneration (seedlings + saplings + poles) density (individuals per ha) was 18.48 ha^{-1} for *T. elliptica* and 73.58 ha^{-1} for *T. paniculata*. Among the total regeneration of *T. elliptica*, 56% were seedlings, 26% saplings and 18% poles. Similarly, regeneration of *T. paniculata* under seedling category was 46%, 24% saplings and 30% poles. With respect to *T. travancorensis*, regeneration density was negligible (0.019 ha^{-1}).

This poor representation might be due to the limited distribution of the species. Regeneration details in each zone are provided in Tables-3 and 4. Regeneration of *T. elliptica* and *T. paniculata* was significantly different (*P≤0.01*) between zones.

Over all regaeneration status of *T. elliptica* was very good (seedlings > saplings > poles) and not satisfactory for *T. paniculata* wherein the observed trend was seedlings > saplings < poles (Table-2). Status of regeneration is decided by proportion of the population of seedlings, saplings and poles[12-14]. In general, good regeneration is represented as the proportion of seedlings > saplings > adults, fair regeneration is by seedlings > or ≤ saplings > adults and poor if the species survives only in sapling stage (saplings may be <, > or = adults)[15].

Table-2: Overall regeneration status of *T. elliptica* in the study sites of Kerala (Values (individuals ha^{-1}) are mean ± SD).

Regeneration categories		*T. elliptica*		*T. paniculata*	
Seedlings (≤3cm collar girth)	< 50 cm height	4.12 ± 1.35	10.35 ± 3.42	9.59 ± 3.13	34.04 ± 14.62
	50-100 cm height	4.53 ± 1.56		17.37 ± 6.43	
	>100 cm height	1.70 ± 0.77		7.08 ± 3.22	
Saplings (3.1 -10 cm Gbh)			4.78 ± 1.89		17.78 ± 7.23
Poles (10.1-30.0 cm Gbh)			3.35 ± 1.46		21.76 ± 9.67
Regeneration (Seedling + sapling + pole)			18.48		73.58

Table-3: Regeneration status of *T. elliptica* in study sites of different zones in Kerala (Values (individuals ha^{-1}) are mean ± SD).

Zones	Regeneration categories					
	Seedlings (≤3cm collar girth)			Total (≤ 3 cm collar girth)	Saplings (3.1 -10 cm Gbh)	Poles (10.1-30 cm Gbh)
	< 50 cm height	50-100 cm height	>100 cm height			
Northern	3.26 ± 0.68	6.38 ± 2.87	1.28 ± 0.58	10.92 ± 5.16	0.43 ± 0.18	0.28 ± 0.09
Olavakkode	9.32 ± 3.27	4.70 ± 1.43	0.96 ± 0.21	14.98 ± 6.83	1.67 ± 0.53	1.20 ± 0.50
Central	4.57 ± 1.75	6.17 ± 2.63	1.17 ± 0.41	11.91 ± 4.37	19.79 ± 7.89	11.28 ± 5.88
High Range	1.77 ± 0.49	2.69 ± 0.88	2.31 ± 0.86	6.77 ± 2.75	2.00 ± 0.55	2.31 ± 0.41
Southern	0.72 ± 0.17	3.81 ± 1.23	2.68 ± 0.98	7.22 ± 2.18	1.13 ± 0.77	2.06 ± 0.54

Table-4: Regeneration status of *T. paniculata* in study sites of different zones in Kerala (Values (individuals ha^{-1}) are mean ± SD)

Zones	Regeneration categories					
	Seedlings (≤3cm collar girth)			Total (≤ 3 cm collar girth)	Saplings (3.1 -10 cm Gbh)	Poles (10.1-30) cm Gbh)
	< 50 cm height	50-100 cm height	>100 cm height			
Northern	7.94 ± 3.58	8.94 ± 3.63	2.84 ± 0.87	19.72 ± 8.52	3.26 ± 1.01	4.82 ± 1.97
Olavakkode	11.39 ± 4.91	16.73 ± 7.46	5.26 ± 1.95	33.39 ± 10.32	17.21 ± 8.28	8.61 ± 2.36
Central	8.83 ± 3.95	12.34 ± 5.78	2.66 ± 0.61	23.83 ± 9.94	34.15 ± 11.14	42.45 ± 15.60
High Range	3.46 ± 1.57	14.38 ± 7.66	8.23 ± 3.74	26.08 ± 11.29	13.00 ± 4.85	21.46 ± 7.84
Southern	17.42 ± 7.10	33.20 ± 11.36	15.26 ± 3.65	65.88 ± 19.09	19.59 ± 6.70	31.44 ± 10.41

A very good regeneration status in *T. elliptica* was reported from Northern and Olavakkode zones; but in Cerntral zone its regeneration was fair and poor in High Range and Southern zones. Similarly, very good regeneration status in *T. paniculata* was reported from Olavakkode zone; however, it was not satisfactory in Northern, Cerntral, High Range and Southern zones. Relative proportion of the categories of regeneration was different due to interactive influence of biotic and abiotic factors[16]. Negligible regeneration in *T. travancorensis* indicates a threat to the species[3,17]. Failure of regeneration in *T.*

travancorensis is due to litter accumulation and closed canopy as reported by others[14,16].

Below 40 per cent canopy cover helped high survival rate of regeneration of the species. An earlier study has also reported a high rate of regeneration in *T. alata* with increased canopy gap[18]. Human intervention and other biotic as well as abiotic factors (fire, grazing, drought, heavy rain and canopy structure of overstorey) may affect regeneration of a species[3,8,9,15,19]. Deficiency of natural regeneration and the improper proportion of regeneration categories may ultimately affect regular distribution of diameter classes and population structure of the species [20,21].

Conclusion

In general, tree density of *T. paniculata* was more than *T. elliptica*. Distribution of *T. travancorensis* was limited to a few sites. Regeneration status of *T. elliptica* was very good compared to *T. paniculata*. A negligible representation of regeneration was reported to *T. travancorensis*. The study concluded with an urgent need of effective silvicultural practice like assisted natural regeneration for conservation of the *Terminalia* species.

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